



ANNUAL MATERNAL MORTALITY RATE FORECASTING FOR SURINAME USING THE DOUBLE EXPONENTIAL SMOOTHING TECHNIQUE

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Abstract

This study uses annual time series data on MMR for Suriname from 1985 to 2023 to predict future trends of MMR over the period 2024 to 2035. The study utilizes Holt's double exponential smoothing model. The optimal values of smoothing constants α and β are 0.3 and 0.9 respectively based on minimum MSE. The results of the study indicate that MMR will drop from around 97 in 2024 to about 45 deaths per 100 000 live births in 2035. Therefore, we encourage authorities to relentlessly attend to major drivers of maternal deaths and channel more resources towards implementation of quality improvement strategies.

Keywords: Exponential smoothing, Forecasting, Maternal Mortality Ratio

Introduction

Suriname is a middle-income country in South America with 583,200 inhabitants (General Bureau of statistics, 2019). The country has an average of 10,000 births in a year, with 86% being reported in the 5 major hospitals, 6% in primary care, 4% at home, and 4% at an unknown location (Suriname, 2019). Although the maternal mortality ratio declined with time from 226 per 100,000 live births in 1991 1993 to 154 per 100,000 live births in 2010, Suriname was chosen by the Pan American Health Organization (PAHO) in 2010 as one of the 10 priority countries in Latin America and the Caribbean for the reduction of maternal mortality (PAHO, 2019; Kodan et al. 2017; Mungra et al. 1999). The objective of this paper is to model and forecast MMR for Suriname using the double exponential smoothing technique. The study results are expected to inform policy



formulation, planning and allocation of adequate resources to the health sector so that preventable maternal deaths are eradicated.

Literature Review

Author(s)	Objective(s)	Methodology	Key finding(s)
Becerra et al. (2026)	to identify and analyze maternal complications associated with adolescent pregnancy, with a particular focus on the Latin American context	qualitative and descriptive approach	adolescent pregnancy in Latin America and the Caribbean entails significant medical risks and negatively affects the integral development of adolescents, a situation that is aggravated by the lack of access to health services, education and by factors such as poverty
Mackin et al. (2026)	to understand how levels of MNH care are organized in different country contexts	Scoping review	Three or four levels of MNH facility care were most commonly reported. Linking maternal and newborn facility care to community connections is an important consideration to ensure equitable access to routine and emergency care
Marks & Castro (2026)	To examine how MWHs have been implemented across Latin America, analyzing their evolution, the specific needs they address in different countries, and their impact on maternal and neonatal health outcomes throughout the region	Systematic review	The evolution of MWHs suggests that they address a spectrum of needs beyond their original purposes, such as providing culturally responsive maternal support and psychosocial and early childhood support
Tsushima et al. (2026)	To determine the long-term incidence of dysglycemia and dyslipidemia after GDM and evaluated whether postpartum changes in body mass index (BMI) independently predicted these outcomes	Prospective cohort study	postpartum weight change may help identify women at higher risk of subsequent metabolic abnormalities, particularly dysglycemia, in this high-risk population, although causal relationships cannot be inferred from this observational study
Yue et al. (2026)	to perform an umbrella review to summarize the current evidence to provide	Systematic literature review	This review offers a thorough overview of the current evidence linking SLE, SS and APS to



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	a reference for clinicians and future research		pregnancy and assisted reproductive outcomes. It identifies existing gaps and proposes future research directions
Cresswell et al. (2025)	To obtain updated evidence on causes of maternal death is needed to accelerate progress	Systematic review	Globally, the most common cause of maternal death was hemorrhage (27%; 80% uncertainty interval 22–32), followed by indirect obstetric deaths (23%, 18–30), and hypertensive disorders (16%, 14–19). The proportion of hemorrhage deaths varied substantially by region and was highest in sub-Saharan Africa and Western Asia and Northern Africa.
Quiroz-Acuña et al. (2025)	To assess maternal mortality trends in LAC women from 1997 to 2019, providing key insights to address this issue.	ecological observational time-series study	Despite overall progress, regional differences in maternal mortality persist across Latin America and the Caribbean. These variations highlight the importance of strengthening maternal health systems, improving access to skilled birth attendance, and ensuring quality prenatal and postnatal care
Silvana et al. (2025)	To describe the factors influencing the reduction of maternal mortality during the 2022–2024 management period at Tartagal Hospital (HT)	Participatory Action Research (PAR) with a qualitative-quantitative analysis. Twelve meetings and interviews were conducted with the healthcare team, along with 10 validated surveys administered to obstetric inpatients (10/12/24), and an analysis of hospital databases	intercultural, comprehensive, and territory-based management of pregnancy and childbirth led to a reduction in maternal mortality beginning in 2022. Teamwork and intersectoral collaboration optimized available resources, consolidating a sustainable and effective model for maternal health. However, the greatest challenge lies in maintaining and increasing funding to ensure the continuity of this policy
Nigenda and Serván-Mori (2024)	To discuss the relationship between the availability of human resources for health and the maternal mortality	used secondary data from a global source to show patterns in the relationship between these two aspects and	Although variations in maternal mortality rate cannot be explained solely through the provision of health personnel, it is important to consider that it is critical to find new



	ratio for the period 1990–2021 in Latin America	identify gaps in the Latin American and Caribbean regions	modalities on how human resources for health could integrate and create synergies with other resources to increase systems capacity to deliver care according to conditions in each country
Critto et al. (2022)	To examine the effects of a pandemic influenza virus on cause-specific maternal mortality time series, using Argentinian vital statistics	-conducted a population-based natural experiment from national vital records of maternal deaths between 1980 and 2017 -applied Join-point regression models	Over this 38-year study, the MMR decreased by 58.6% (69.5 to 28.8 deaths/100,000 live births), transitioning from direct obstetric causes (67.0 to 21.1/100,000 live births; 68.4% decrease) to indirect causes (2.6 to 7.7/ 100,000 live births; 196.2% increase)
Lachmi et al. (2021)	To describe the process of MDSR implementation in Suriname and share the “lessons learned,” as experienced by the health care providers, national maternal death review committee members, and public health experts. Before 2015, maternal deaths were identified using death certificates and by active surveillance in the hospitals	Implementation research	One of the main barriers to implementing MDSR in Suriname has been the lack of action following recommendations.
Verschueren et al. (2020)	to assess MNM and associated factors in middle-income country Suriname by applying the three different MNM tools	A nationwide prospective population-based cohort study was conducted using the Suriname Obstetric Surveillance System (SurOSS)	The MNM ratio in Suriname is comparable to other countries in the region. The WHO-tool underestimates the prevalence of MNM (high mortality-index), while the adapted tools may overestimate MNM and compromise global comparability
Verschueren et al. (2020)	to evaluate the current perinatal registry, analyze national childbirth outcomes and study ethnic disparities in middle-income country Suriname, South America	A nationwide birth registry study was conducted in Suriname	Disaggregated perinatal health data in Suriname shows substantial inequities in outcomes by ethnicity



Kodan et al. (2018)	to perform a qualitative analysis of the clinical and management aspects of sepsis-related maternal deaths with a focus on the 'golden hour' principle of antibiotic therapy	A nationwide reproductive age mortality survey was performed from 2010 to 2014 to identify and audit all maternal deaths in Suriname	The study concluded maternal mortality could be reduced by improving early recognition and timely diagnosis of sepsis, vital signs monitoring and immediate antibiotic infusion (within the golden hour)
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Methodology

This study utilizes an exponential smoothing technique to model and forecast future trends of MMR for Suriname. In exponential smoothing forecasts are generated from the smoothed original series with the most recent historical values having more influence than those in the more distant past as more recent values are allocated more weights than those in the distant past. This study uses the Holt's linear method (Double exponential smoothing) because it is an appropriate technique for modeling linear data.

Holt's linear method is specified as follows:

Model equation

$$A_t = \mu_t + \rho_t t + \varepsilon_t$$

Smoothing equation

$$S_t = \alpha A_t + (1 - \alpha) (S_{t-1} + b_{t-1})$$

$$0 < \alpha < 1$$

Trend estimation equation

$$b_t = \beta (S_t - S_{t-1}) + (1 - \beta) b_{t-1}$$

$$0 < \beta < 1$$

Forecasting equation

$$f_{t+h} = S_t + h b_t$$

A_t is the actual value of MMR at time t

ε_t is the time varying **error term**

μ_t is the time varying mean (**level**) term

ρ_t is the time varying **slope term**

t is the trend component of the time series

S_t is the exponentially smoothed value of MMR at time t

α is the exponential smoothing constant for the data



β is the smoothing constant for trend

f_{t+h} is the h step ahead forecast

b_t is the trend estimate (slope of the trend) at time t

b_{t-1} is the trend estimate at time t-1

Data Issues

This study is based on annual MMR in Suriname for the period 1985– 2023. The out-of-sample forecast covers the period 2024 – 2035. All the data employed in this research paper was gathered from the World Bank online database.

Findings of the study

Exponential smoothing Model Summary

Table 1: ES model summary

Variable	A
Included Observations	39
Smoothing constants	
Alpha (α) for data	0.300
Beta (β) for trend	0.900
Forecast performance measures	
Mean Absolute Error (MAE)	8.488773
Sum Square Error (SSE)	6135.097130
Mean Square Error (MSE)	157.310183
Mean Percentage Error (MPE)	-0.130795
Mean Absolute Percentage Error (MAPE)	5.563883



Residual Analysis for the Applied Model

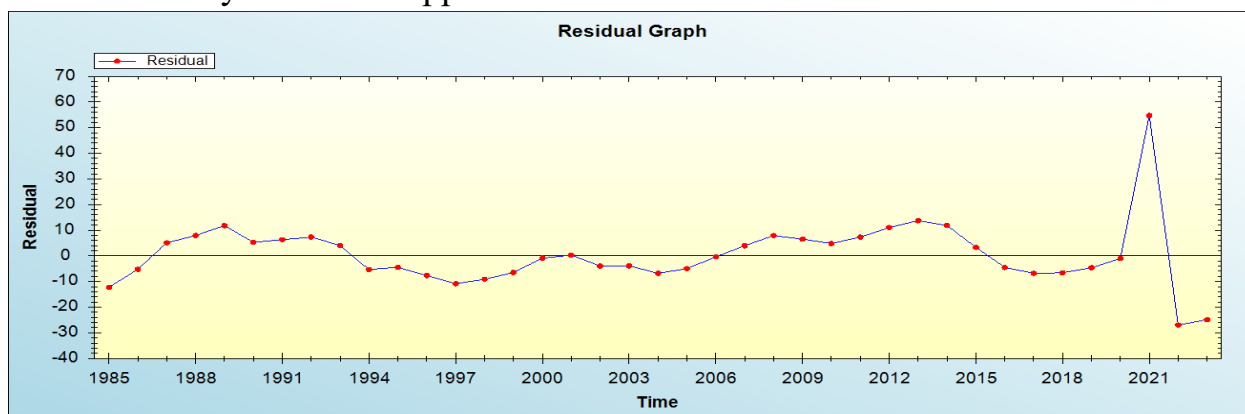


Figure 1: Residual analysis

In-sample Forecast for A

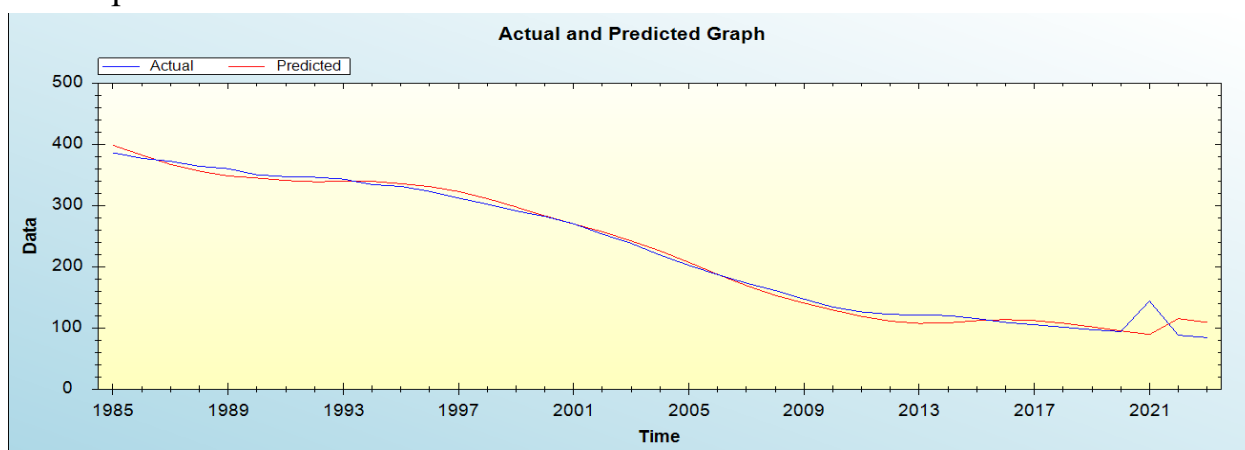


Figure 2: In-sample forecast for the A series

Actual and Smoothed graph for A series

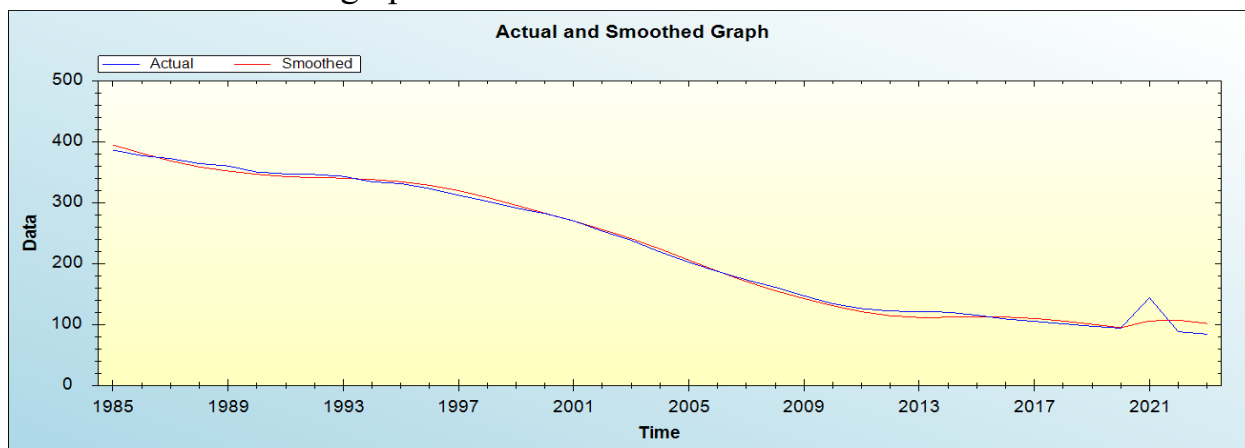


Figure 3: Actual and smoothed graph for A series



Out-of-Sample Forecast for A: Actual and Forecasted Graph

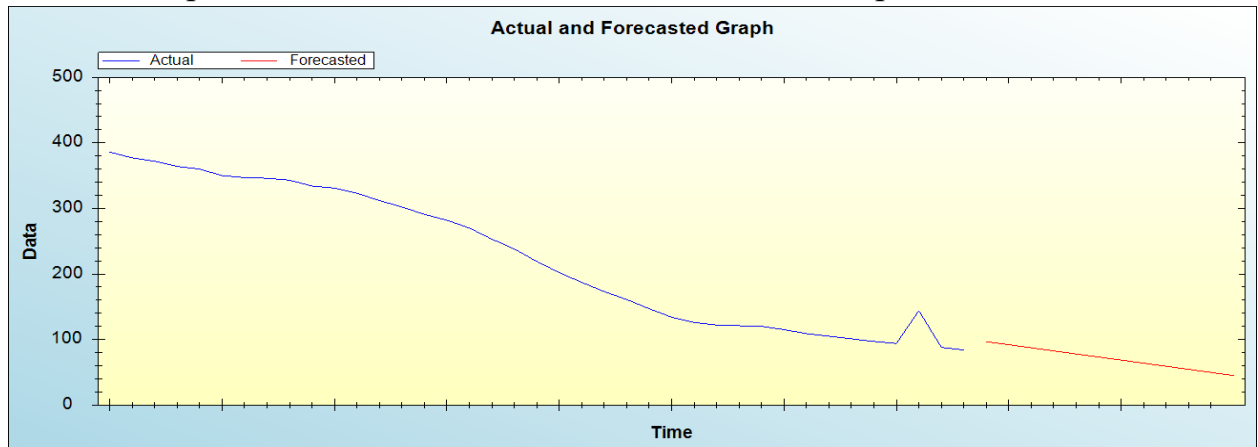


Figure 4: Out-of-sample forecast for A: actual and forecasted graph
Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	96.7234
2025	92.0228
2026	87.3222
2027	82.6215
2028	77.9209
2029	73.2203
2030	68.5196
2031	63.8190
2032	59.1184
2033	54.4177
2034	49.7171
2035	45.0165

The main results of the study are shown in table 1. It is clear that the model is stable as confirmed by evaluation criterion as well as the residual plot of the model shown in figure 1. It is projected that annual MMR will drop from around 97 in 2024 to about 45 deaths per 100 000 live births over the out of sample period.



Conclusion

This paper applied the double exponential smoothing technique to model and forecast MMR for Suriname and findings suggest that MMR will drop from around 97 in 2024 to about 45 deaths per 100 000 live births in 2035. Hence, we implore authorities to tirelessly attend to local causes of maternal deaths with priority being given to the improvement of the quality of maternal healthcare services across the country.

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